Abstract Submitted
for the MAR15 Meeting of
The American Physical Society

Synthesis and Investigation of van der Waals Heterostructures KATHLEEN MCCREARY, AUBREY HANBICKI, JAMES CULBERTSON, MARC CURRIE, BEREND JONKER, Naval Research Laboratory — The recent isolation of single layers of transition metal dichalcogenides (TMD) has demonstrated that reducing dimensionality can alter the material properties. In particular, MoS_2, $MoSe_2$, WS_2, and WSe_2 exhibit an abrupt transition from indirect to direct bandgap semiconductors at monolayer thickness. Monolayer TMDs are promising materials for electronic components due to their high mobility, high on/off ratio, and low standby power dissipation. Additionally, selective layer-by-layer stacking to form van der Waals (vdW) heterostructures may provide the ability to controllably engineer electronic, optic, and spintronic properties. Recently, several methods were investigated to achieve vdW heterostructures including sequential exfoliation, stacking of chemical vapor deposition (CVD) grown monolayers, and epitaxial growth of bilayers. We detail our CVD synthesis of the monolayer TMDs (MoS_2, $MoSe_2$, WS_2 and WSe_2) and the subsequent fabrication and characterization of vdW heterostructures. In our heterostructures, we observe a dramatic decrease in PL intensity compared to the monolayer constituents. The Raman spectra exhibit clear and distinct differences from a superposition of monolayer spectra, demonstrating that interactions across the van der Waals interface in these heterostructures may significantly modify the net electronic properties. We find the observed behaviors are influenced by many factors, including charge transfer, substrate effects, stacking sequence, as well as intra- and inter-layer exciton formation, which will be discussed here.

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Date submitted: 14 Nov 2014 Electronic form version 1.4